ADVANCES IN MATERIALS ENGINEERING

Volume 1

Edited By:
Zahurin Halim
Iskandar Idris Yaacob
Md Abdul Maleque

IIUM PRESS
INTERNATIONAL ISLAMIC UNIVERSITY MALAYSIA

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Published by:
IIUM Press
International Islamic University Malaysia

First Edition, 2011
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Perpustakaan Negara Malaysia Cataloguing-in-Publication Data

ISBN: 978-967-418-167-3

Member of Majlis Penerbitan Ilmiah Malaysia – MAPIM
(Malaysian Scholarly Publishing Council)

Printed by :
IIUM PRINTING SDN. BHD.
No. 1, Jalan Industri Batu Caves 1/3
Taman Perindustrian Batu Caves
Batu Caves Centre Point
68100 Batu Caves
Selangor Darul Ehsan

Table of Content

Chapter 006

Quality of Copper Film Electroplated on Silicon Wafer Using Different Current Densities

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Keywords: Copper electroplating, current density, silicon wafer, barrier layer, texture, surface roughness

Abstract. Copper film was electroplated on silicon wafer surfaces using a H2SO4 electrolyte at a current density ranging from 30 to 90 mA/cm2. The silicon wafer substrate had a diffusion barrier layer of IMP Ta, IMP TaN, CVD TiN or PVD TiN and a Cu seed layer over the underlying barriers. The influence of current density on the quality of the electroplated Cu film has been investigated in terms of texture, surface morphology and surface roughness. The growth of the Cu film is generally in <111> preferred orientation under all plating conditions. The degree of growth in <111> orientation is higher on both CVD TiN and PVD TiN barrier layers compared to those on IMP Ta and IMP TiN. The film became strongly orientated in <111> direction when electroplated at a current density of 60 mA/cm2. Electroplating at a 90 mA/cm2 current density produced Cu film textured in <200> direction. The surface roughness reduced significantly by electroplating at an increasing current density. The grains of Cu film were finer after electroplating at a higher current density compared to that plated at a lower current density. The growth of the Cu film was mostly columnar with equiaxed grains near the surface and at the interface.

Introduction

Texture and the surface morphology of metal deposits are strongly affected by crystal properties of the depositing metal as well as by mass and charge transfer across the interface boundary. The growth process of a crystal depends on the crystallographic character of the growing surface and is mainly affected by the surface structure itself. The surface of a solid metal substrate has a complex character. Areas occupied by crystallites on the surface with different crystallographic orientations and intergrain boundary regions can be differentiated.

Textures is the preferred distribution of grains (individual crystalline) having a particular crystallographic orientation with respect to a fixed reference frame. It is an important structural parameter for bulk materials and coating. Electrodeposition on a randomly oriented polycrystalline substrate can result in development of preferred orientation, or texture, in deposits. In a polycrystalline material crystallographic axes of individual grains constituting polycrystal are fixed (have the same orientation) with respect to the axes of the reference system, the polycrystalline material exhibits preferred orientation or texture. The development of texture can occur during deposition or during the postdeposition processing.

The competitive growth model of development of texture during deposition is based on the idea that different crystal faces have different rates of growth. Thus, there is a growth rate competition between crystalline of various orientations. Crystallites of various orientations could be generated either during preferrential nucleation process or during the competitive growth mechanism